

Budget and capabilities of information technology governance: empirical analysis in higher education institutes

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ABSTRACT

Despite empirical improvements in Ecuador's higher institutes in preparing for information technology (IT) governance, much remains to be done to improve understanding of the maturity of governance structures, processes, and relational mechanisms with the referential budget allocated to IT departments. In this sense, the objective of the work is to analyze the maturity of the IT governance mechanisms and the referential budget allocated, from the relational and predictive point of view, going through a descriptive process. The data that was analyzed comes from the 2020 opinion survey, conducted by a group of researchers with support from the National Secretariat of Higher Education, Science, Technology, and Innovation of Ecuador. In total, 18 institutes completed the survey with budget information. The findings show the considerable absence of internal processes, weak positive, and negative relationship between variables; and the low level of maturity of the mechanisms of IT governance capacities, for the time being, is not significant for the institutional budget. In conclusion, this analysis can provide a baseline to assist in the preparation of action plans for institution-building. In addition, it allowed identifying several weaknesses and strengths, not only in institutions but also in research.

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1. INTRODUCTION

Higher technical, technological, and pedagogical institutes; and higher conservatories of music and arts, which are part of the higher education system of Ecuador are classified as public and private [1]–[3]. Educational management includes the exercise of the functions of the authorities of the higher hierarchical level; whose responsibilities would reach the conformation of the institutional corporate governance [2]. The budget, among other options, will be constituted by the resources assigned by the executive function to public institutes; and income from tuition, rights, and fees, with the exceptions established in the constitution and in the Organic Law of Higher Education (OLHE) in Higher Education Institutions (HEI) [2].

Faced with this institutional scenario, the governance of information technology (IT) is presented as an important component of institutional governance [4], [5]. As an integral part of this government [6], IT governance is the responsibility of the executive council because they own the strategic decision-making process and control the institutions [7]. Considered a system that helps organizations manage the risks of losses associated with technology [8] and determine if they are getting value from IT budgets [9], [10]. As institutions

increasingly rely on IT to improve their business performance, IT governance has a positive effect on business products and processes [11], becoming a focus problem in multiple areas of the institution [12].

It is known that some institutions, such as the center for information systems research (CISR) at the MIT Sloan School, have conducted research on the impact of IT governance on companies in many industrial sectors [9]. According to Lunardi *et al.* [4] have stressed the need to observe benefits from IT investments or use over longer time, especially because some IT investments will have short time effects and others will have longer-term impacts. According to Wu *et al.* [13] proposes a nomological model that allows for creating organizational value through IT governance mechanisms through the discovery of positive, significant, and impactful links between IT governance mechanisms, alignment strategy, and organizational performance. Research by Ryu *et al.* [14] investigated the relationships between IT budgets and IT governance structures concluding that there is a negative correlation between IT budgets and IT resources. Furthermore, they found a positive correlation between IT and IT governance decision-making structure when IT governance structure is more centralized, which means that IT resource management becomes more efficient and easier to manage. In this sense, it is important to continue studying the IT budget as a function of variables related to the possibilities of obtaining benefits through IT governance mechanisms.

Previous research has emphasized the strategic and growing importance of IT governance in all organizations and how it affects performance and budgets. More specifically, as the next section of this paper shows, a large body of IT governance literature targets executive management or organization-specific attributes, such as leadership or commitment, as determinants of IT governance. However, it is still relevant to look for other IT governance factors that generate a return on the IT budget. Considering the abundant literature on the influence of executive management demographics and demographic diversity on strategic decisions, and the fact that, to the best of our knowledge, there have been no studies on executive management diversity as an antecedent of IT governance, the objective of this study is to explore the degree of use of the mechanisms IT governance in the profiles of the demographic diversity of executive management.

This study contributes to the IT governance literature by providing new insights into the context of IT governance. Based on our sample, we developed three demographic diversity profiles, showing that different “mixtures” of executive insight and knowledge gained through education, industry experience, and seniority produce different outcomes in terms of IT governance adoption levels—mechanisms that can lead to. Organizations can determine which of these profiles best suits their needs based on their IT governance needs.

2. BACKGROUND

2.1. Higher education institutions

According to art 14, literal of the OLHE [2], higher technical, technological, pedagogical, and art institutes, both public and private, duly evaluated, and accredited, are also HEIs. Similarly, art 182 of the same law, establishes that the National Secretariat of Higher Education, Science, Technology, and Innovation (Senescyt) is the body whose purpose is to exercise the stewardship of the public policy of higher education and coordinate actions between the Executive Branch and HEIs. The responsible autonomy exercised by HEIs, among other aspects, consists of the freedom to prepare, approve, and execute the institutional budget; the freedom to acquire and manage their assets in the manner provided by law; and the freedom to manage resources in accordance with the objectives of the development regime. In Ecuador, there are a total of 186 higher institutes with a current academic offer. Of these, 91 are public and 95 are private, according to the portal of the higher education council (HEC) of Ecuador [15].

2.2. IT governance

IT governance has several definitions according to the study perspective. From a behavior-based view, the most important [16] is the proposal of the ISO/IEC 38500 standard [17], which says: “the system by which the current and future use of IT”. This definition, like another vision based on behavior [18], supposes the direction, evaluation, and monitoring of the IT use plans that support the organization through performance indicators. On the other hand, a process-based vision is found in the COBIT 2019 proposal [19], which says: “it is interested in the delivery of value derived from digital transformation and the mitigation of business risk that results from said digital transformation”. This definition assumes the management processes in the management of IT resources and risks, through the management of budget projects and their prioritization. Similarly, there are other proposals with definitions of each author that involve the good governance of IT [20] and responsibilities and rights in decision-making over a wide range of IT resources. Research by Selig [21], the approach to processes, structures, and relational mechanisms with defined responsibilities for business/IT alignment [22], managerial capacity for IT strategies [23], the definition of

organizational control structures adding value and balanced risk [24], effectiveness and efficiency in the use of IT [25], organizational competence that facilitates the exercise of authority [26], decision-making structure and administrative process [27], among others.

2.3. IT governance capabilities

The genesis of IT governance began with studies that analyzed the forms of IT governance [28]–[30] and considered multiple contingencies for IT governance [31]. In the last decade, many researchers have begun to understand the influence of different governance mechanisms on the effectiveness of IT governance in different organizational contexts, [4], [10], [13], [24], [32]–[37] and the understanding of coordination as a process and of IT governance in federated organizations [38]. Despite the differences in the definitions of IT governance, similarities arise in the proposals to implement the governance system based on structural mechanisms, process mechanisms, and relational mechanisms with the aim of improving business/IT alignment. Similarly, research shows positive associations between IT governance mechanisms and performance within the organization.

However, as we can see, research has only examined the relationships of certain IT governance mechanisms with IT governance performance. We believe that there is still a lack of research addressing the three IT governance mechanisms and their relationship, not only with strategic alignment but also with the IT budget. For example, Wu *et al.* [13] show that IT governance structures, processes, and communications are effective mechanisms to promote the intellectual dimension of strategic alignment of information systems because they provide an institutionalized context that enables social understanding between IT and business executives from a corporate level that also includes the senior management team.

In the process of mapping out this paper between IT governance mechanisms and IT budget in higher education institutions, it is useful to have a definition of the important elements of an IT governance framework. In this sense, the works of [39]–[42] propose and demonstrate that IT governance can be implemented through a combination of twelve structures, eleven processes, and ten relational mechanisms (see Table 1). The structures involve clearly defined roles and responsibilities and a set of business/IT committees, such as IT steering committees and business strategy committees. Processes refer to formal strategic decision-making, planning, and monitoring processes to ensure that IT policies are consistent with business needs. Finally, relational mechanisms, which include business/IT interaction and collaborative learning and communication, are crucial to the IT governance framework.

Table 1. IT governance capabilities coding

Structural	Procedural	Relational
S1-Strategy committee at the board level	P1-Strategic planning of information systems	R1-Work rotation
S2-IT experience at board level	P2-IT performance measurement (e.g., IT balanced scorecard)	R2-Co-location
S3-(TI) audit committee at the board level	P3-Portfolio management (business cases, ROI, payback)	R3-Cross-training of managers
S4-CIO on the executive committee	P4-Chargeback arrangements: total cost of ownership (for example, activity-based costing)	R4-Knowledge management (on the governance of IT)
S5-CIO reporting to the CEO/rector	P5-Service level agreements	R5-Business/IT alignment management
S6-IT steering committee (executive-level IT budget assessment/prioritization)	P6-IT governance framework COBIT or other	R6-Executive/senior manager giving good example practices
S7-Is an IT governance officer on duty?	P7-IT governance assurance and self-assessment	R7-Informal meetings between business executives and IT executives/senior managers
S8-Is there a security/compliance/risk officer?	P8-Project governance/methodology	R8-IT Leadership
S9-IT Project steering committee	P9-IT budget control and reporting	R9-Internal corporate communication addressed to IT on a regular basis
S10-Information security steering committee	P10-Benefits management and reporting	R10-IT governance awareness campaigns
S11-Institutional architecture steering committee	P11-COSO/ERM	
S12-Integration of governance tasks/alignment in roles and responsibilities		

Undoubtedly, these mechanisms cannot be adopted by all organizations, but they must be considered useful on the path to adequate governance; therefore, they must be configured with effort according to the nature of the organization so that they help mitigate the risks associated with it and help in the creation of value in the business. According to Peterson [39], the so-called IT governance capabilities described in the table above show a layered system of successively higher levels of horizontal integration capability (HIC). HICs consist of a combination of connection, coordination, and collaboration mechanisms. Connection and coordination describe the formal structures and processes used for information exchange and communication, while collaboration describes an element of participatory and collaborative integration, which corresponds to trust and the willingness to work together between business and IT stakeholders.

In other words, IT governance capabilities describe the lateral structures, processes, and relational skills for directing and coordinating the multifaceted activities associated with planning, organizing, and controlling IT. Designing effective IT governance architectures involves both differentiating and integrating IT decision-making by IT and business stakeholders, and underscores the need to address both the assignment of formal authority to IT decision making as the coordination of expertise and influence in IT decision making. According to Lunardi *et al.* [4], the adoption of IT governance capabilities can help organizations mitigate risks associated with IT and create business value from IT; however, lack of budget alignment with the business and failure to use benchmarks or metrics except for financials will affect performance.

There is evidence that the adoption of IT governance capabilities can lead organizations to manage and use the technology they apply to business more efficiently than companies where IT governance is not effective and that this is reflected in the overall performance of the organization. The adoption of IT governance would have direct and indirect effects on the business processes that, together, determine the overall performance of the company [43]. One reason to invest in effective IT governance is to increase profitability. Organizations expect to have some positive impact on profits when they invest in IT, achieving both revenue growth and cost savings [44]. IT can help businesses reduce or avoid marketing, management, and operating costs. The deployment of IT systems has improved the efficiency of operational and supply chain processes within and between companies by supporting transformation efforts [45].

The level of maturity of the IT governance capabilities ensures the budget of IT in the Technical and Technological Institutes of Ecuador. In this regard, it is hypothesized that effective IT governance driven by structural, procedural, and relational mechanism capabilities will be significantly and predictively related to the level of IT funding. This research motivates us to carry out a relational and predictive analysis of IT governance capabilities with IT budgets in Ecuadorian HEs; for this, the research model shown in Figure 1 is defined.

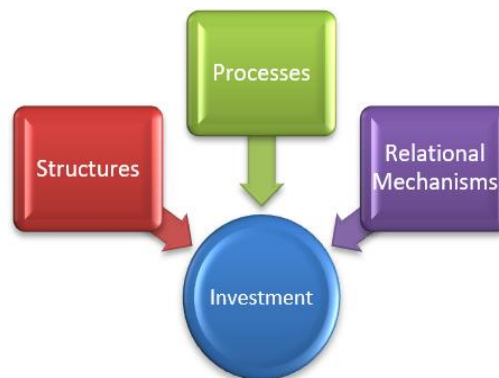


Figure 1. Research model

3. RESEARCH METHOD

The research is empirical with a descriptive and correlational scope [46]. Spearman's non-parametric correlation method was used because it is most appropriate for ordinal data (maturity level) and numerical data (budget). Once the Spearman correlation is found, the correlation measure with spearman's Rho coefficient is applied. What was evaluated is the funding of each institution, as well as its level of maturity by IT governance capacity with the funding. It uses an IT governance capabilities framework to test the research model defined in Figure 1. In this sense, the methodology was structured in the following steps: i) preparation of the study objects, ii) design of the cross-sectional survey [47], and iii) execution of the questionnaire. Finally, the data are identified and proceed with the analysis between variables [48], [49]; subsequently, conclusions and future work in the discipline are presented.

3.1. Study subjects

First, it is necessary to understand that a sample, in the quantitative aspect, is a subgroup of the population or universe that we are interested in knowing, on which the relevant data will be collected, and must be complete and representative of that population [46]. The process that was followed to select the sample begins in the determination of the sampling unit that are the institutes, followed by the delimitation of population, then the sampling strategy, then the size is determined and finally the units of analysis were selected. In this sense, the probabilistic method was used to select the members of the sample. The survey was open for two months. In Ecuador, there are a total of 186 higher institutes with a current academic offer. The survey was sent to 71 institutions, of which only 18 reported on the reference budget for information technology. However, it can result in an unrepresentative sample with a high level of error and moderate confidence, but it is necessary to consider that in Ecuador budget information is very difficult to be provided. With this information we proceeded with the descriptive and correlational analysis. The number of participating institutes is in the following order: 6 public (33.33%) and 12 private (66.66%) for a total of 18 institutions of higher education.

3.2. Control variables and survey management

This paper examines the influence of independent variables, represented by IT governance capabilities (structures, processes, and relational mechanisms), on the dependent variable (IT budget). Each of its governance capabilities is defined through its key mechanisms. Each key mechanism is evaluated according to one of six levels: 0–non-existent, 1–initial, 2–repeatable but intuitive, 3–defined, 4–managed and measurable and 5–optimized. The assessment of each key mechanism allows maturity to be calculated.

Before operationalizing the survey, a review of understanding and comprehension was carried out with two researchers and two research assistants, whose results confirmed the clarity and consistency of the terminology adopted in each question. The request to participate in the study and instructions for completing the survey were emailed to the institutes' CIOs. Each of the IT leaders provided their maturity opinion through the survey. Survio's website (www.survio.com) was used to operate the survey, through which it was possible to consolidate the opinion data of IT leaders. Then, with IBM SPSS Statistics 22 [50] the data were processed for the analysis of related factors.

4. RESULTS AND DISCUSSION

4.1. Descriptive analysis

Regarding the level of key mechanisms disaggregated by institution, the results by structures, processes and relational mechanisms that are shown in Figures 2 (a)-(c), show that the 18 institutes have an irregular level by mechanism and by capacity. The greatest weakness of the capacities according to this level is in the processes (see Figure 2(b)); this demands an effort to improve. In institutes, the maturity of the mechanisms does not have a uniform behavior. In the opinion of the participants, there are some useful observations. The participation of the levels, by structural capacity, is an interesting indicator to measure the IT governance activity in an institution. An institution with a consolidated rising level and a formal IT governance system is usually a more engaged and competitive institution. Additionally, it tends to be an institution with a wide and varied simple activities to carry out. On the other hand, institutions with a consolidated low level and without an IT governance system are usually fewer dynamic institutions where there is greater improvisation and dependence on initiatives.

Figure 3 presents the level as a percentage of maturity of the institutions for twelve mechanisms of structure in six levels of maturity. It can be observed that, except for the S2 mechanism (IT experience at the board of directors), level 0 has the highest participation in all structure mechanisms, with the S8 mechanism (security/compliance/risk officer) having the lowest maturity and the S12 (integration of governance tasks/alignment in roles and responsibilities) having the highest maturity. Figure 4 presents the level as a percentage of maturity of the institutions for eleven process mechanisms at six levels of maturity. It can be observed that, except for the P1 mechanism (strategic planning of information systems), level 0 also has the highest participation in all process mechanisms, with mechanism P11 (COSO/ERM) having the highest participation. On the positive side, the percentage of institutes with level 5 of maturity in the P9 mechanism (IT budget control and reports) stands out.

Figure 5 shows the level as a percentage of the maturity of institutions for ten relational mechanisms at six levels of maturity. Level 0 also has the highest participation, mainly in mechanisms R3 (cross-training of managers), R5 (business/IT alignment management), and R10 (IT governance awareness campaigns). On the positive side, the percentage of institutes with level 5 maturity in the R8 (IT leadership) mechanism stands out. Table 2 shows that the variables under study do not have a normal distribution of frequencies; therefore, the significance values obtained allow for the acceptance of the research test.

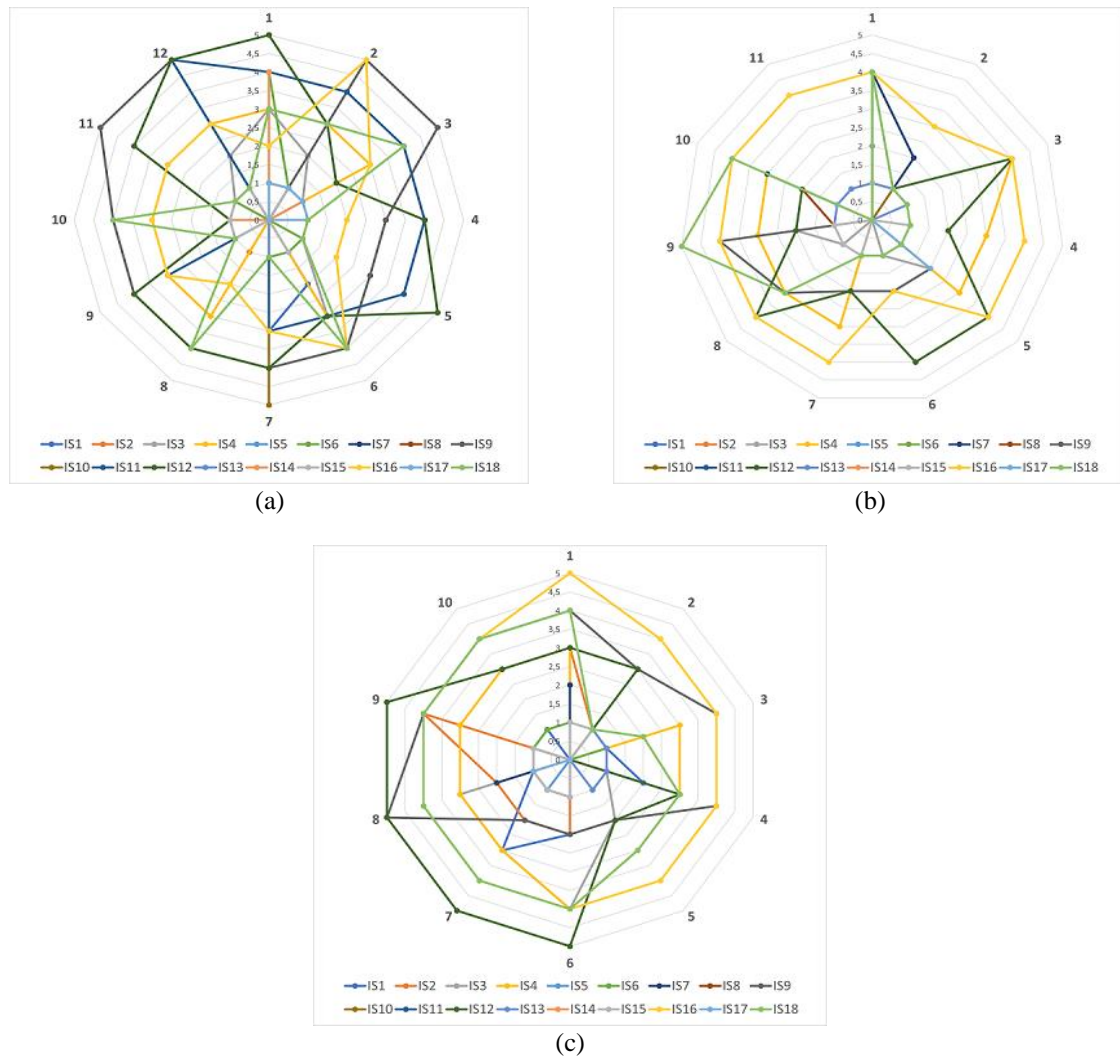


Figure 2. Level of key institutional mechanisms by capacity (a) structures, (b) processes, and (c) relational mechanisms

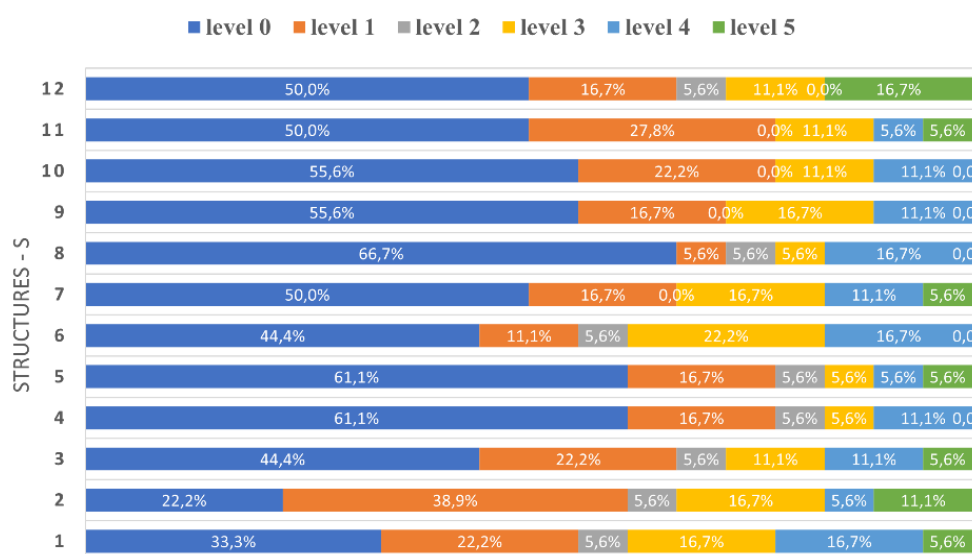


Figure 3. Percentage of the total by job position

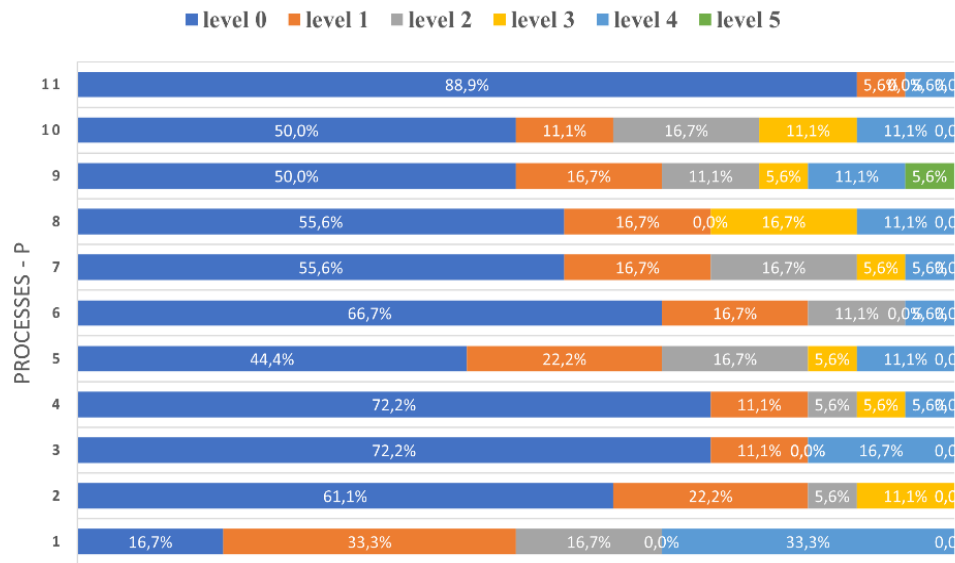


Figure 4. The maturity level of processes mechanisms

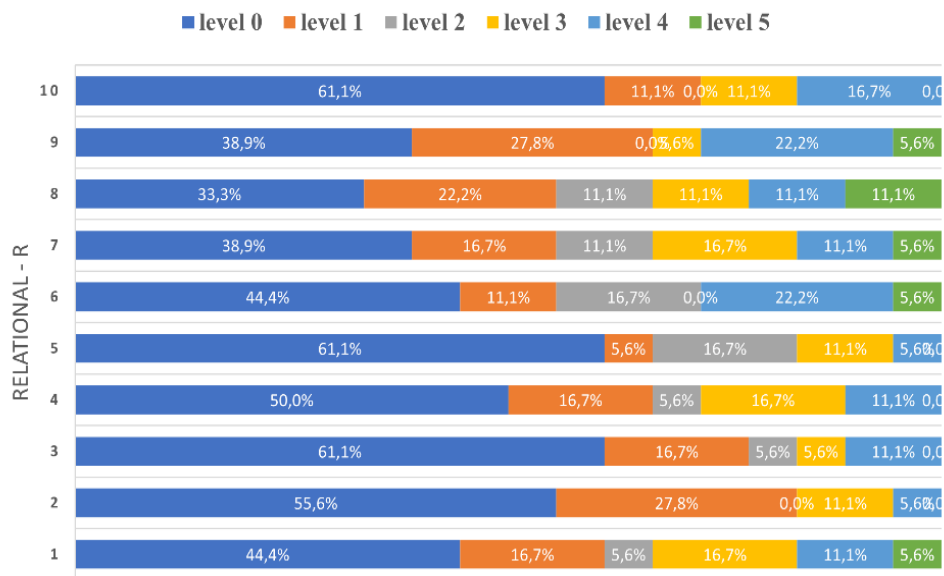


Figure 5. The maturity level of relational mechanisms

Table 2. Test of normality Shapiro-Wilk

Structure	Statistic	Sig.	Processes	Statistic	Sig.	Relational	Statistic	Sig.
Constant	0.464	0.000	Constant	0.464	0.000	Constant	0.464	0.000
S1	0.859	0.012	P1	0.820	0.003	R1	0.817	0.003
S2	0.853	0.009	P2	0.687	0.000	R2	0.701	0.000
S3	0.802	0.002	P3	0.550	0.000	R3	0.679	0.000
S4	0.679	0.000	P4	0.595	0.000	R4	0.772	0.001
S5	0.680	0.000	P5	0.806	0.002	R5	0.727	0.000
S6	0.793	0.001	P6	0.638	0.000	R6	0.802	0.002
S7	0.773	0.001	P7	0.757	0.000	R7	0.855	0.010
S8	0.643	0.000	P8	0.722	0.000	R8	0.856	0.011
S9	0.722	0.000	P9	0.776	0.001	R9	0.787	0.001
S10	0.706	0.000	P10	0.792	0.001	R10	0.676	0.000
S11	0.736	0.000	P11	0.333	0.000			
S12	0.744	0.000						

4.2. Relational and predictive analysis

When analyzing capabilities with IT funding, it is thought that the system's capability mechanisms are significantly related to IT funding. Table 3 shows that there are no significant (strong) relationships at the level of $p < 0.01$ and $p < 0.05$; this means that if the opinions of the HEIs are aware there is no 99% or 95% probability that the confidence interval contains the true value that strengthens the relationship of capabilities with the budget. By analyzing the structural variables individually, it is thought that the mechanisms of the structural capacities of the system modify the budget of the IT. That is, the twelve structural mechanisms and the six levels of maturity (ordinal data) were compared by mechanism. Table 4 shows that the probability (p-value) in each of the structural capacities is higher (mayor error) than the significance level of 0.05, concluding that there are differences between the groups analyzed or evaluated; that is, the level of maturity of the mechanisms of structural capacities does not change the budget of IT.

Table 3. Spearman's rho correlations

Structural		Budget Processes		Relational	
S1	0.146 <i>0.564</i>	P1	-0.039 <i>0.879</i>	R1	0.104 <i>0.680</i>
S2	0.139 <i>0.584</i>	P2	0.290 <i>0.244</i>	R2	0.316 <i>0.202</i>
S3	-0.009 <i>0.973</i>	P3	0.407 <i>0.094</i>	R3	-0.025 <i>0.922</i>
S4	0.087 <i>0.731</i>	P4	0.334 <i>0.175</i>	R4	0.162 <i>0.521</i>
S5	-0.032 <i>0.899</i>	P5	0.107 <i>0.671</i>	R5	0.034 <i>0.895</i>
S6	0.074 <i>0.770</i>	P6	0.093 <i>0.715</i>	R6	0.130 <i>0.608</i>
S7	0.340 <i>0.168</i>	P7	0.266 <i>0.285</i>	R7	0.083 <i>0.743</i>
S8	0.088 <i>0.729</i>	P8	0.152 <i>0.548</i>	R8	-0.030 <i>0.907</i>
S9	0.118 <i>0.642</i>	P9	0.093 <i>0.713</i>	R9	0.365 <i>0.136</i>
S10	-0.190 <i>0.451</i>	P10	0.149 <i>0.556</i>	R10	0.021 <i>0.933</i>
S11	0.001 <i>0.998</i>	P11	0.411 <i>0.090</i>		
S12	0.139 <i>0.581</i>				

Table 4. Kruskal Wallis test-structures

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Chi-Square	5.615	4.972	3.999	3.674	3.669	1.618	2.004	0.196	1.596	0.710	0.004	1.375
<i>p-value</i>	0.060	0.083	0.135	0.159	0.160	0.445	0.367	0.907	0.450	0.701	0.998	0.503

The case of the budget variable shows a behavior similar to that of structural; thus, in Table 5 it is observed that the probability (*p-value*) for each of the variables is greater (mayor error) than the significance level of 0.05, which corroborates the presence of significant differences between the different study groups; that is, the level of maturity of procedural capabilities mechanisms does not change IT funding. Finally, about the relational variable, within its individualized analysis, when considering a null hypothesis "the distribution of the aleatory variable is not different from the normal distribution". Table 6, similar to the previous results, shows that its probabilities (p-value) are greater (mayor error) than the significance level of 0.05. In this sense, it is concluded that if there are differences between the groups evaluated, that is, the level of maturity of relational capabilities mechanisms does not change IT funding.

As institutions invest in IT in acquiring IT resources to improve business processes, IT-related capabilities that benefit from IT governance initiatives should also contribute to comprehensive business process improvement. A capability-based study allows us to understand the effectiveness of IT governance and the importance of mapping the relationship between IT governance and IT-related capabilities at the process and organizational level [32]. Another study suggests that the adoption of IT governance practices is associated with improvements in different financial metrics and the maturity of IT governance initiatives can affect government performance [4]. The emergence of new structural, procedural, and relational mechanisms

presents institutions with opportunities to improve capacities in response to the needs demanded by the beneficiary groups. These mechanisms show interesting challenges for institutions in the search for new levels of maturity supported by IT governance practices. In this sense, the exploratory and descriptive study analyzes the mechanisms with the budget in higher education institutions.

Table 5. Kruskal Wallis test–processes

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Chi-Square	0.412	1.050	3.931	0.950	1.454	3.445	1.086	1.481	1.500	3.537	5.506
<i>p</i> -valor	0.814	0.591	0.140	0.622	0.483	0.179	0.581	0.477	0.472	0.171	0.064

Table 6. Kruskal Wallis test–relational

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Chi-Square	0.143	2.032	2.101	3.634	2.358	0.255	0.321	0.374	1.249	2.049
<i>p</i> -valor	0.931	0.362	0.350	0.163	0.308	0.880	0.852	0.829	0.536	0.359

5. CONCLUSION AND FUTURE WORK

When applying the Kruskal-Wallis ANOVA test, in relation to the normality test and starting from the null hypothesis "the distribution of the random variable is not different from the normal distribution", in each of the case studies, grouped into structural capacity, processes, budget, and relational variables, the probabilities are greater than the significance level of 0.05; showing the presence of differences between the groups evaluated. This leads to the conclusion that the maturity of the mechanism, based on the structural, procedural, and relational system, does not affect the budget presented by the technical institutes of higher education. As evidenced in the findings, the null hypothesis "the population averages are equal in each of the groups" has been rejected, both in the capacity of the structure, procedure, budget, and relational variable; therefore, the data do not come from the same distribution or from the same population, when considering the non-parametric method.

This study tried to improve the understanding of the importance of the maturity of IT governance mechanisms by harnessing the value of IT. Specifically, it was found that there is a relationship between positive and negative mechanisms with budget, but very weak. It is inferred that the lack of internal processes in the institutes induces the low capacity related to IT. This capability-based IT governance analysis used applied statistics to provide a more adequate explanation of the determinants in the initiatives implemented in the institutions.

For decision makers, our study reiterates the initiative that IT governance is truly an effort that must be worked on in a coordinated and articulated manner, which must take into account all mechanisms that generate value for the business. This understanding is important because stakeholders evaluate the financial aspects of their decisions. However, the impact that mechanisms generate in organizations depends on the maximum benefit they can get from their capabilities. Beyond the limitations in the analysis sample, we encourage researchers to consider this theoretical-practical procedure when evaluating the effectiveness of other IT governance mechanisms in relation to how they can contribute to development. Similarly, future research will consider other IT governance mechanisms and IT related capabilities to strengthen our understanding of the articulation of IT governance.

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